IMPROVING THE ENERGY CONSUMPTION AND ENVIRONMENTAL IMPACT ASPECTS OF MILITARY BASE CAMP OPERATIONS THROUGH THE USE OF SUPECRITICAL WATER OXIDATION TECHNOLOGY

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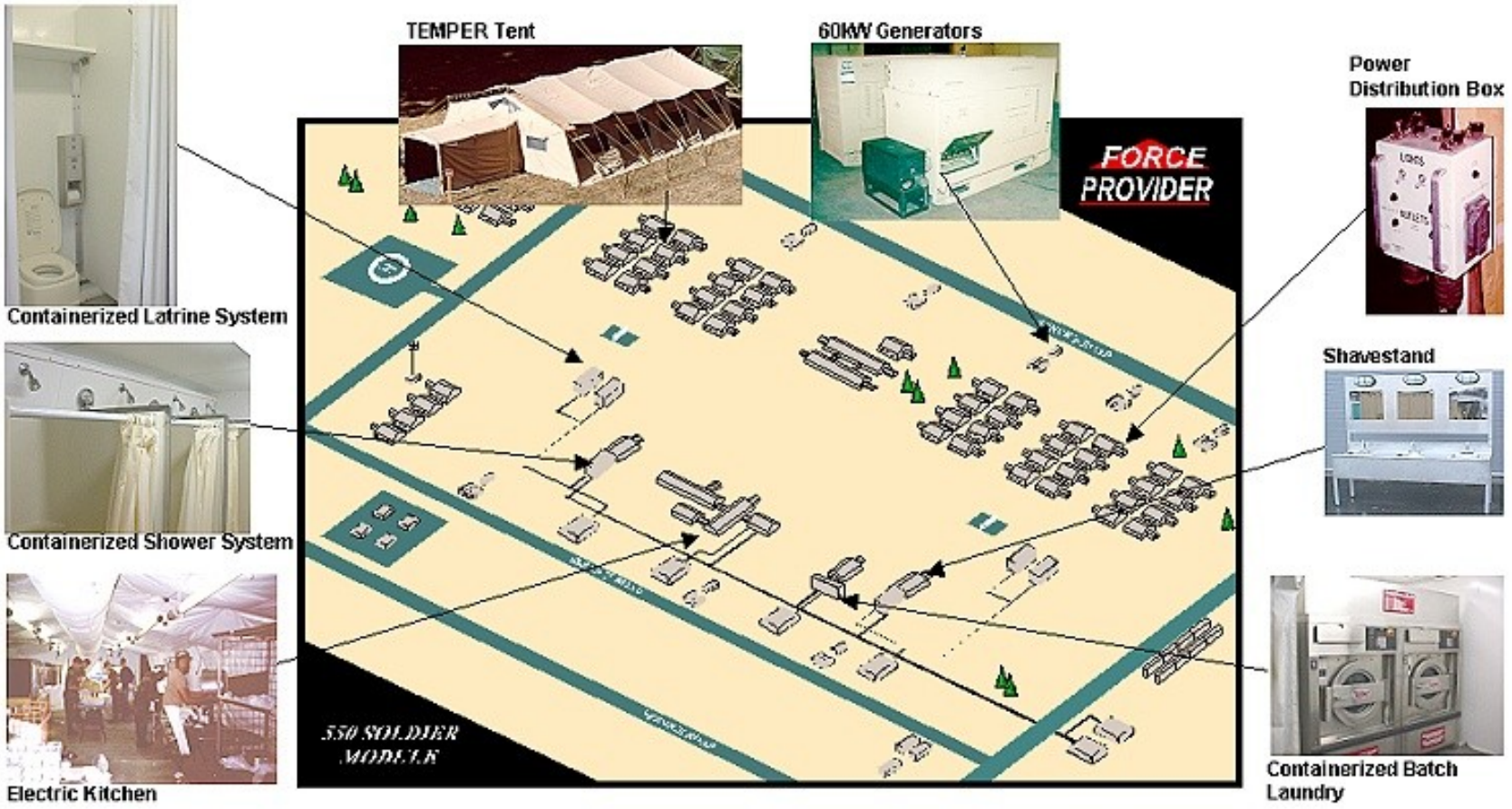
OUTLINE

- Force Provider – an introduction.
- Supercritical Water Oxidation – an introduction.
- Sample SCWO application to Force Provider
- Cost benefit analysis
- Conclusions

FORCE PROVIDER MODULE



Source: http://peocscss.tacom.army.mil/pmFP/pm_fss/products/images/fpmore.jpg

FORCE PROVIDER MODULE SUMMARY

- Capacity
  - 550 individuals
- Potable Water Requirement
  - 20,000 gpd
- Services
  - Containerized Kitchen (CK)
  - Containerized Shower (CS)
  - Containerized Latrine System (CLS)
  - Containerized Batch Laundry (CBL)

- Waste Water Production

Service	Units	H_2O Req. [gpd]	TSS (max) [mg/L]	TDS (max) [mg/L]
Kitchen	1	1,900	2,557	9,044
Laundry	1	5,200	125	578
Shower	2	11,000	107	502
Latrine	4	3,500	1,450	2,563

Source: U.S. Army Soldier Systems Center in Natick, MA

FUEL, WATER AND WASTE

FUEL SUPPLY

FUEL

CAMP

WASTEWATER HOLDING

FUEL

WATER PURIFICATION

POTABLE WATER

WASTEWATER

BRINE HOLDING

BRINE

WASTE
DSIPOSAL

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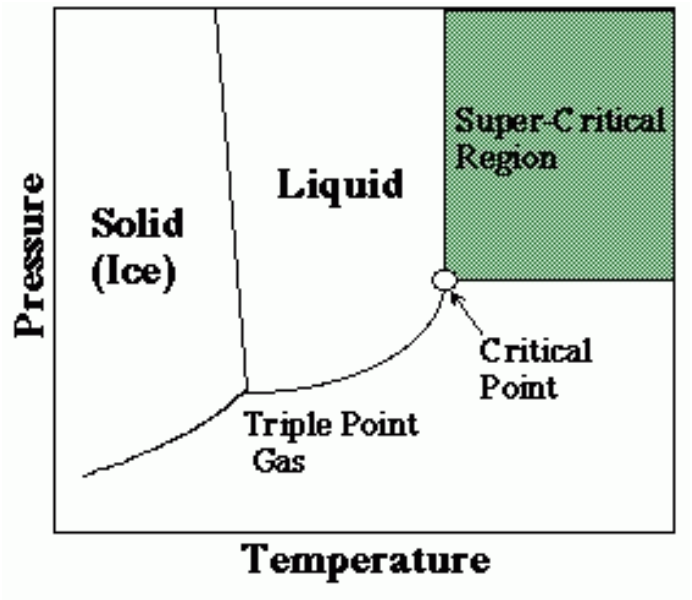
SUPERCRITICAL WATER



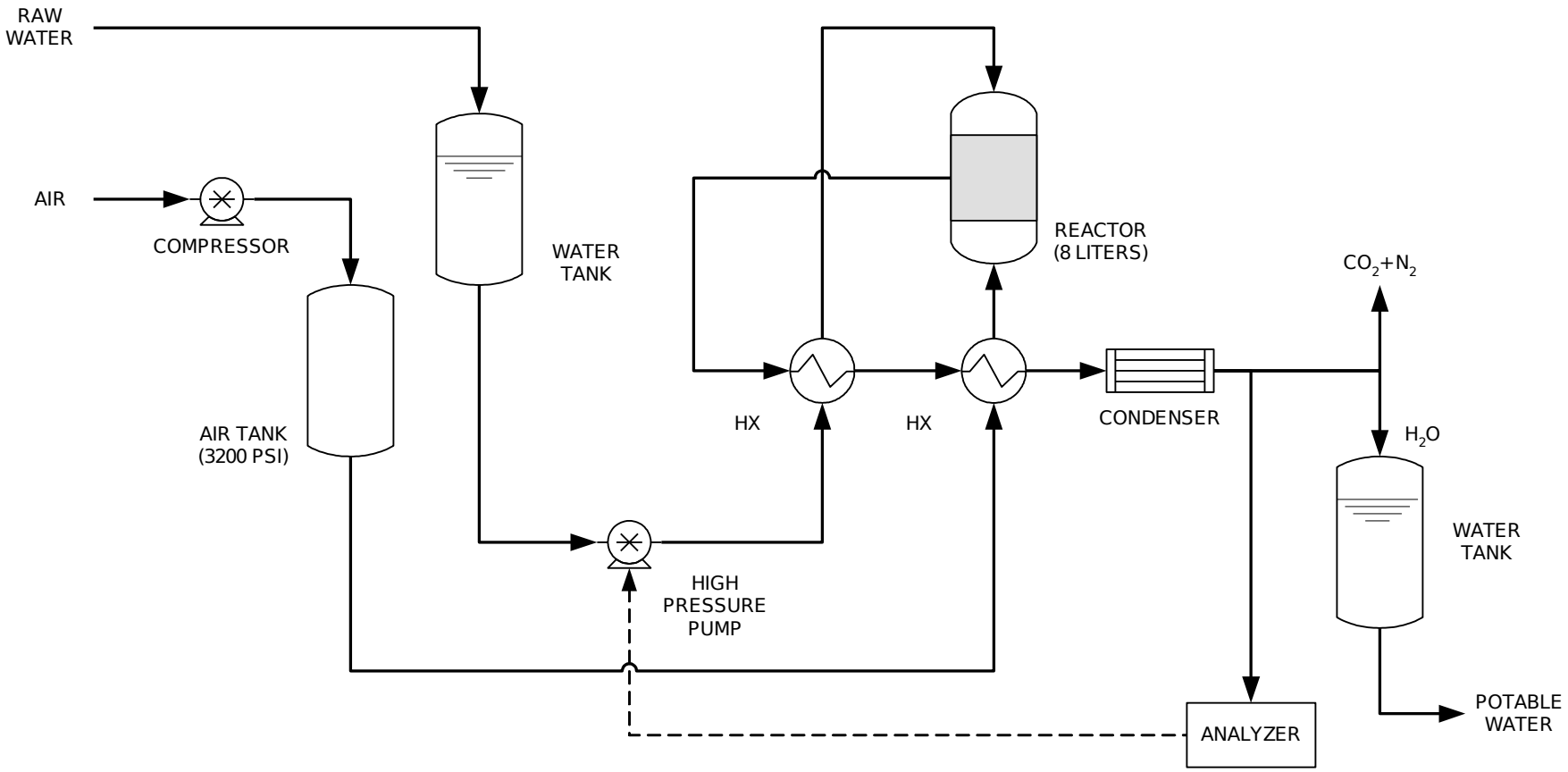
AMBIENT		SUPERCRITICAL	
• Negligible (Low)	Organic Solubility	Very High	⇦
• Very High	Inorganic Solubility	Negligible (Low)	⇦
• High (No Control)	Density	Mod High (Controllable)	
• High	Viscosity	Low	
• Low	Diffusivity	High	
• 80	Dielectric Constant	5.7 @ critical point	
• High	Polarity	Low	
• None	Corrosiveness	Some	
• Fire Extinguishing	Oxidation	Combustion medium	⇦
• 9.2mg/L	Oxygen Solubility	Any proportion	⇦

Critical Temperature: 374 ºC (705 ºF)

Critical Pressure: 218 atm (3200 psi)

Source: University of Missouri - Columbia

SUPERCRITICAL WATER OXIDATION



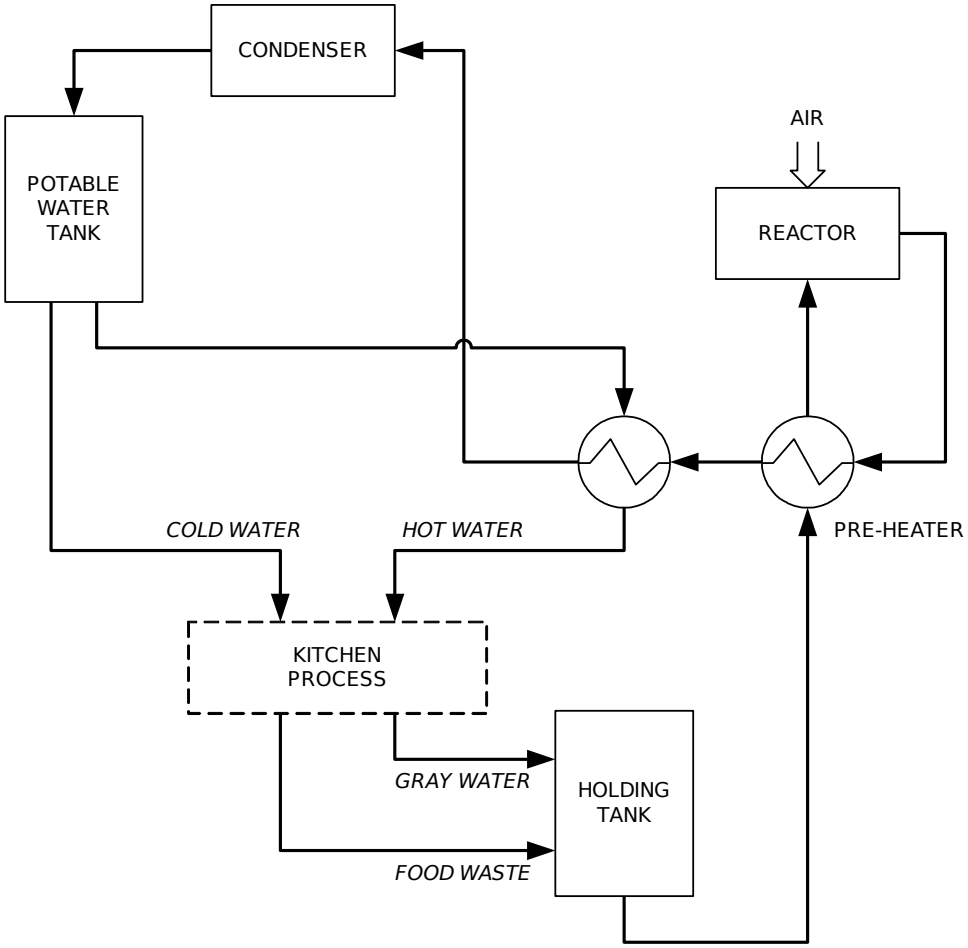
SCWO BENEFITS

- Environment friendly process.
  - uses only water and air.
  - reaction products are H_2O, CO_2 and N_2.
  - waste consists of ash and salts.
- Unlimited solubility of oxygen… oxidation reaction is complete.
- Destruction efficiency is 99.9999% (6 log10).
- No production of NO_x, THM, THM precursors, DBP, or brine.
- No filters accumulating biological or chemical agents.
- Effectiveness is irrespective of feedstream composition.
- Self-sustaining with sufficient organic material in feedstream.

CONTAMINATION	RESIDENCE TIME
• Micro-organisms	<1 sec
• Hydrocarbons	<10 sec
• Soil	<10 sec
• Biological Agent	<30 sec
• Polymeric	<60 sec
• PCB	<200 sec

Source: University of Missouri - Columbia

SAMPLE SCWO APPLICATION - KITCHENS



COST BENEFIT ANALYSIS - CASES

- Remote water production / remote waste disposal.
- Local water production / remote waste disposal.
- Remote water production / local water reclamation.
- Local water production / local water reclamation.

COST BENEFIT ANALYSIS MODEL

$$C_{total} = C_{prod_H2O} + C_{rec_H2O} + C_{truck_H2O} + C_{truck_waste}$$

RO PROCESS

$$C_{prod_H2O} = \frac{E_{RO} \cdot V_{H2O_req}}{E_{JP8} \cdot \eta_{gen}} \cdot C_{fuel}$$

$$C_{rec_H2O} = 0$$

$$C_{truck_H2O} = \frac{V_{H2O_req}}{V_{truck}} \cdot 2 \cdot D_{base} \left(\frac{C_{truck}}{v_{truck}} + \frac{C_{fuel}}{mpg_{truck}} \right)$$

$$C_{truck_waste} = \frac{(1-\alpha) \cdot V_{H2O_req}}{V_{truck}} \cdot 2 \cdot D_{base} \left(\frac{C_{truck}}{v_{truck}} + \frac{C_{fuel}}{mpg_{truck}} \right)$$

SCWO PROCESS

$$C_{prod_H2O} = \frac{E_{RO} \cdot \alpha \cdot V_{H2O_req}}{E_{JP8} \cdot \eta_{gen}} \cdot C_{fuel}$$

$$C_{rec_H2O} = \frac{E_{SCWO} \cdot (1-\alpha) \cdot V_{H2O_req}}{E_{JP8} \cdot \eta_{gen}} \cdot C'_{fuel}$$

$$C_{truck_H2O} = \frac{\alpha \cdot V_{H2O_req}}{V_{truck}} \cdot 2 \cdot D_{base} \left(\frac{C_{truck}}{v_{truck}} + \frac{C_{fuel}}{mpg_{truck}} \right)$$

$$C_{truck_waste} = 0$$

COST BENEFIT ANALYSIS MODEL (cont.)

FUEL COST

$$C_{fuel} = C_{DESC} + C_{depot} + C_{tanke}$$

$$C_{depot} = 1300$$

$$C_{tanker} = \frac{tanker_{cost}}{tanker_{capacity}} \cdot 2 \cdot D$$

$$tanker_{cost} = \frac{tanker_{acq_cost} + tanker_{sup_cost}}{tanker_{life} \cdot tanker_{wear}}$$

Fiscal Year	Price Per Gallon of Fuel
1999	0.83
2000	0.62
2001	1.01
2002	1.00
2003	0.84
2004	0.91

ENERGY

$$E_{RO} = 15 \frac{W \cdot h}{gal}$$

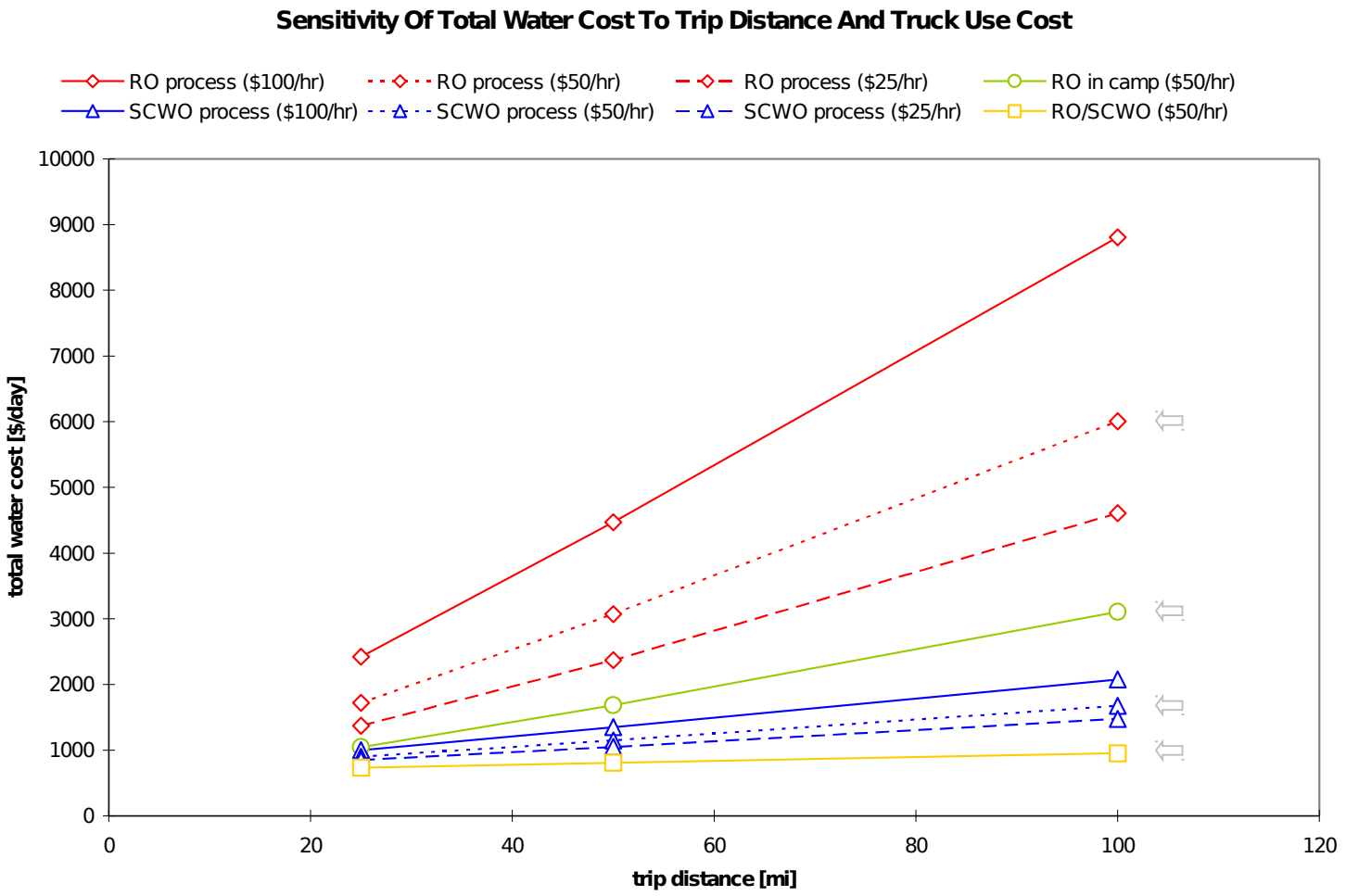
$$E_{SCWO} = 23 \frac{W \cdot h}{gal}$$

$$E_{JP8} = 36{,}088 \frac{W \cdot h}{gal}$$

EFFICIENCY

$$\eta_{gen} = 0.26$$

COST BENEFIT SENSITIVITY ANALYSIS



COST BENEFIT ANALYSIS OBSERVATIONS

- Transportation cost dominates total cost of RO approach.
  - reduction of production cost offers minimal improvement.
- RO total cost obtained is a lower bound.
  - ignores chemicals and filters.
- SCWO total cost obtained is an upper bound.
  - ignores organic material in wastewater.
  - ignores energy rejected by diesel generator set.

CONCLUSIONS

- SCWO improves energy consumption…
  - allows on-site reclamation of water.
  - reduces the need to transport potable water in.
  - minimizes the need to transport waste water out.
  - reduces number of vehicles on road.
  - reduces fuel consumption.
- SCWO improves environmental impact…
  - minimizes the disposal of organic and inorganic waste.
  - eliminates the need to dispose of hazardous waste.
- Additionally, SCWO opens the door to…
  - use of energy stored in organic waste material.
  - use of energy wasted by diesel generator sets.